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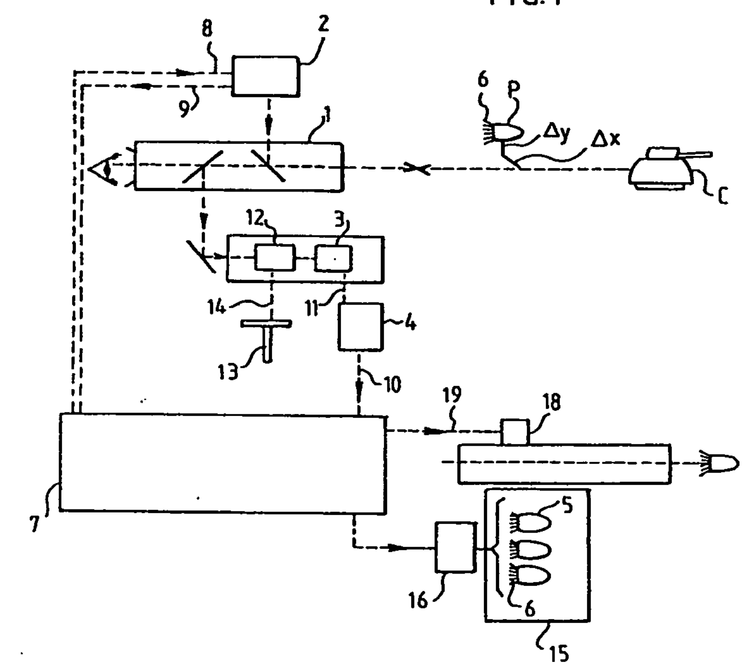
(54) Correcting, from one shot to the next, the firing of a weapon

(57) The target (C) is aimed at with an optical sight (1) throughout the travel of the projectile fired (P), a point representative of the optical axis of the sight passing through the target is formed permanently on a detection surface (3), the projectile is fired and illuminated with a pulse of light from a laser range-finder (2) in order to obtain a reflection from the projectile and the reflected pulse is used in order to form on the detection surface (3) a point representative of the position of the projectile, the deviation (Δx, Δy) of this point from the point representative of the optical axis is measured and the result of this measurement is used out in order to control the next shot. The invention relates to all weapons firing a projectile having a flat trajectory.

FIG.1



This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978.

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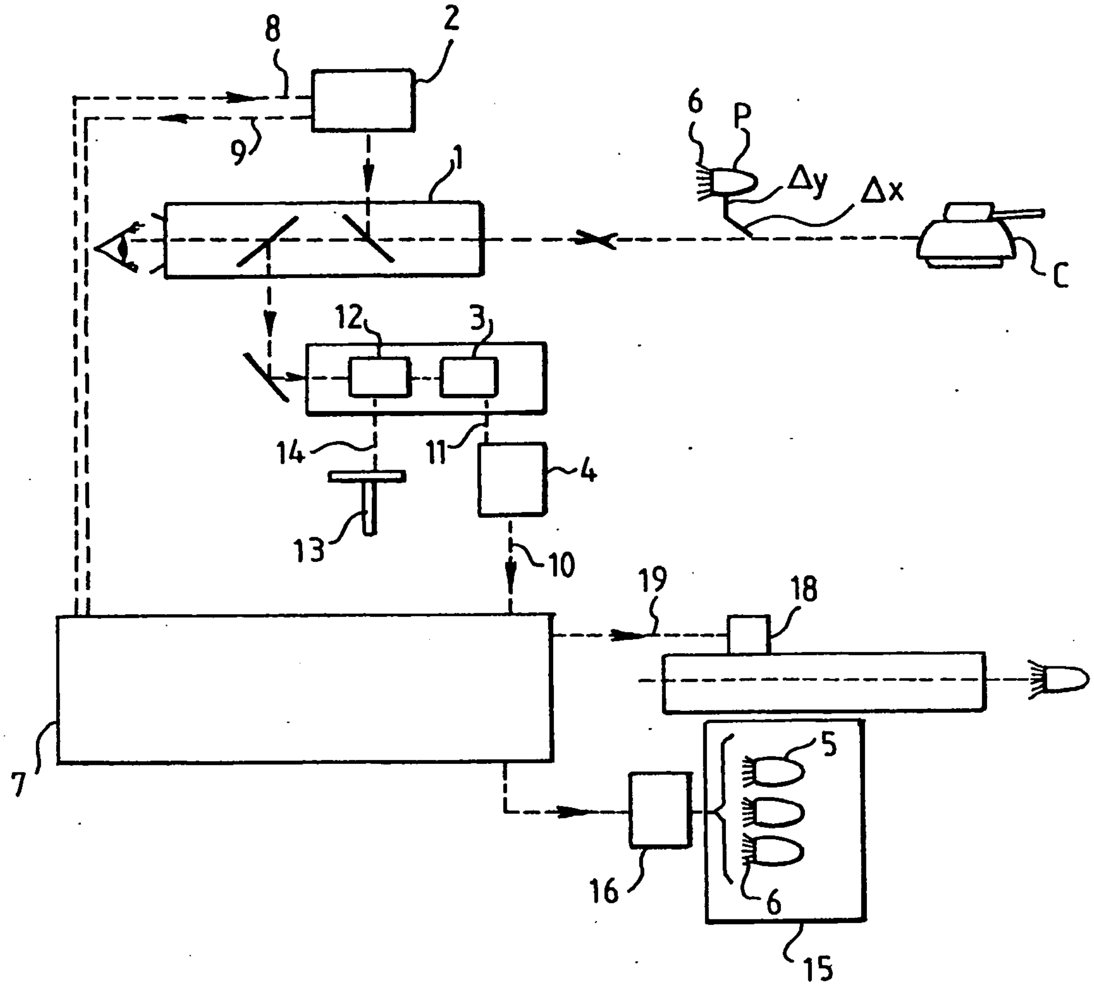
FIG.1



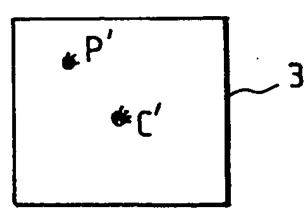


FIG. 2

SPECIFICATION

Method and device for correcting overall, from one shot to the next, the firing of a weapon firing a projectile with a flat trajectory

The invention relates to weapons which fire a projectile having a flat trajectory, i.e. weapons whereof the projectiles describe a trajectory whereof the deflection is slight relative to the distance covered, for example, a deflection of the order of 1% of the distance or less.

The firing accuracy of weapons firing projectiles with a flat trajectory (gun, rocket) has been improved considerably in recent times. On the one hand, this is due to the intervention of improved sights, of measurement pick-ups intended to establish the value of numerous parameters which are involved in the firing calculations and finally by the use of high-speed and accurate calculators which process the information received from these pick-ups and transmit firing adjustments to the barrel.

However, the intervention of these means does not make it possible to reach the high levels of probability of impact which are necessary today in order to eliminate the enemy with even greater certainty in a short period of time.

In fact, they do not make it possible:

to measure the environmental conditions (wind direction, air density etc.) encountered by the projectile on its trajectory, which conditions have a particular influence on the trajectory of a rocket flying very close to the ground;

to take into account possible defects of the firing means (curvature and wear of the barrel of the weapons for example) or of the correction means (lack of harmonization);

to take into account accidental or systematic errors committed by the above means and errors inherent in said means.

The object of the present invention is to provide a method and a device which make it possible to correct the firing, from one shot to the next, taking all the sources of error into account overall.

According to a first aspect of the present invention, there is provided a method for correcting overall, from one shot to the next, the firing of a weapon firing a projectile with a flat trajectory, in which a target is aimed at with an optical sight throughout the duration of travel of the projectile fired, a point representative of the optical axis of the sight passing through the target is formed permanently on a detection surface, the projectile is fired and illuminated with a pulse of light in order to obtain a reflection on the projectile and the return of the reflected pulse is used in order to form on said detection surface a point representative of the position of the projectile, the deviation of this point from the point representative of the optical axis is measured and the result of this measurement is used for controlling the next shot.

According to a second aspect of the present invention there is provided a device for carrying out the method defined in the immediately preceding paragraph, the device being characterised in that it comprises, in combination, means for aiming at the target and forming permanently during the travel of the projectile, an image of the target on a detection surface, means for illuminating the projectile with light pulses, means on the projectile for reflecting said pulses towards the sight, in order to form an image of the projectile on said surface and means for calculating the deviation of the projectile from the sighting axis of the target from said images.

Different methods of correcting a shot are already known.

U.S. Patent 4 015 258 describes a method of supplying the marksman with visual information about the position of the projectile in actual time at the presumed moment of impact, that is, when the projectile is at the same distance as the target. This method is based on the reflecting of laser pulses by the projectile. When the target is situated in an atmosphere of smoke or dust, which is generally the case when the target is a land vehicle, the reflecting of laser signals is greatly disturbed in the immediate vicinity of the target and detection of the position of the projectile in this region is very difficult.

Patent DE-2 827 856 describes a method of supplying the marksman with qualitative information about the position of the projectile when it is presumed to be close to the target, the area of observation of the projectile being divided into a left hand region and a right hand region, and the observation of the projectile taking place when it is at a distance less than that of the target and at a distance greater than that of the target.

The method makes it possible to avoid an observation of the projectile at the presumed moment of impact, but it is only qualitative.

The present invention concerns a quantitive method based on a determination of the possible of the projectile at the presumed moment of impact obtained without using an actual observation of the projectile at that moment.

According to the invention, the distance of the projectile from the sighting axis is measured at a selected moment before the presumed moment of impact, calculation is made from this measurement, and, by extrapolation of the trajectory of the projectile, the distance of the projectile from the target at the presumed moment of impact, and this distance is used to correct the next shot.

The presumed moment of impact is calculated, by a method which is known in itself, from the determination of the distance of the target and the firing parameters (nature of the projectile, atmospheric conditions, etc.).

The selected moment before this presumed moment is chosen in order that the projectile is situated close to the target, but outside the zone which is perturbed by the target. This moment is such, for example, that the projectile has travelled over 95% of its theoretical trajectory, for example, when the projectile is situated 100 metres in front

of the target when the trajectory is 2 kilometres. In terms of duration of covering the distance, if the theoretical duration of travel is 2 seconds, this moment is 1.8 seconds after the departure of the projectile.

The trajectory which must be extrapolated after this final measurement of the distance of the projectile from the sighting axis, is determined by calculation using the distance from the target and the firing parameters or determined by means of the observations of the projectile between its departure and the said selected moment.

The said selected moment need not be a single one.

The determination of the distance of the projectile from the sighting axis at the selected moment or moments can be carried out by any suitable means. For example, by a method which is known in itself, the projectile is equipped with a retro-reflector, the projectile is illuminated with a beam or laser pulses (it is of advantage if it is the same laser beam as the one used for aiming at the target), the return of the reflected pulses is used to form a representative point of the position of the projectile on a detection surface, the trace of the sighting axis of the target is formed on the same detection surface and the metric distance of the projectile from the sighting axis is calculated from the coordinates of the said trace and the said point and from the determination of the distance of the projectile at the said selected moment.

In a preferred embodiment, the method of the invention is therefore a method in which:—

1. A target is aimed at continuously by a manual or automatic operation with an optical sight, i.e. the optical axis of the sighting device is passed through the target in the above mentioned conditions;

2. The image of the trace of the said axis is permanently formed on a flat photoelectric detection surface, arranged preferably perpendicularly to the said optical axis;

3. Luminous pulses, for example generated by a laser associated with the sighting device, are emitted in such a manner that the distance sighting device—target is measured;

4. The time or presumed flight plan of the projectile to be fired which corresponds to this distance is taken from a data storage;

5. The projectile is fired in the best direction known "a priori" owing in particular to a firing computer;

6. The image of the abovementioned range-finder pulses sent back by the projectile is formed continuously or at moments programmed in time, on the photosensitive surface defined in 2.; the projectile can be equipped with advantage for this purpose with an adequate reflecting surface placed at its rear (for example trihedron, rectangle);

7. The distance between the sight and the projectile is measured permanently or at moments programmed in time;

8. At the same moment or moments, the discrepancy between the image defined in 6. and the case defined in 2. above is measured according to two axes passing through the said trace;

9. The metric position of the projectile in relation to the optical axis of the sight is deduced from the measurements defined in 7. and 8. continuously or at programmed moments;

10. The position or the trajectory of the projectile measured in this manner is compared, continuously or at programmed moments, with that (or those) predetermined by a computer which can be the one quoted in 5. above, in order to determine the discrepancy between the trajectory or trajectories or presumed and actual position (s) of the projectile at the moment of the theoretical impact;

11. These discrepancies are used to repeat a better adjusted shot.

An optical sight is understood to mean any sighting device which makes use of the sufficiently linear propagation properties of electromagnetic waves, whether visible or invisible, of short wave length.

A sight which is stabilised by means of a gyroscope is preferably used.

Provision is made for measuring the slope of the optical axis of the sight in relation to the horizontal plane which passes through the sight by means of a vertical sensor.

This vertical sensor can control an optical means of rectifying the projectile image in order to keep one of the two axes of the system of coordinates of the photosensitive surface horizontal.

The distance, obtained according to the method of the invention, between the projectile and the target at the presumed moment of impact is used to correct the following shot.

It will be understood that the following shot need not be the shot which immediately follows and that the word shot can apply to one projectile or to a series of projectiles.

Similarly, the word "correction" must be taken in the widest sense. It may be a question of a correction introduced into the computation parameters or a correction introduced into the result of the calculation or a correction in the method of calculation.

The correction can also be an inhibition of the following shot.

A device for carrying out the method of the invention will be described hereafter with reference to the figures of the accompanying drawings in which:

Fig. 1 is a general diagram of the device; and
Fig. 2 is a diagram of the detection surface.

The device illustrated in Fig. 1 for reaching a target C with a projectile P typically comprises an optical sight 1 where of the optical axis is shown in broken line and passes through the target C, equipped with a laser range-finder 2 (this may be the one which is normally provided on the sight of the weapon used for firing projectiles having a flat trajectory). Associated with the sight is an optronic device comprising a surface 3 (Fig. 2) on

which an image C' of the target C and an image P' of the projectile P may be formed at the same time.

The detection surface is any known detection surface for example of the type scanned electronically or mechanically like a visible or infra-red television screen, or of the type composed of a mosaic of static detectors or of a combination of these types. Known means 4 are associated with the optronic device for calculating the relative coordinates of the two images P' and C'.

In order to obtain the image of the target, the marksman aims at the latter continuously by means of the sight 1 throughout the entire duration of travel of the projectile and the trace of the sighting axis forms the image of the target on the optronic surface 3. It is recommended to use an automatic target-tracking device.

In order to obtain a workable image of the projectile P, the latter is provided with a rear reflector or slightly diffusing base 6 and the latter is illuminated by one or more light pulses emitted by the range-finder 2, preferably as late as possible during the period of travel of the projectile in order that the correction which will be made from the measurement of measurements of deviation occurs solely after the projectile has been subjected to the maximum amount of influences, i.e. solely when it has arrived in the immediate vicinity of the target. The return of the light pulse has a double function: it makes it possible to determine by the intermediary of 4 the deviation of the projectile and sighting axis and through the intermediary of the range-finder 2, the distance between the projectile and sight. At the instant of the return of each laser pulse, the marksman will have at his disposal the distance of the projectile and its angular deviation with respect to the sighting axis, thus by a simple calculation its metric deviations Δx, Δy with respect to said axis, if the latter are necessary.

Firing of the weapon is normally controlled by a firing calculator and programmer 7. This calculator controls the operation of the laser emitter of the range-finder 2 (as shown diagrammatically by the connection 8) and it receives the information from a distance provided by the range-finder (as shown diagrammatically by the connection 9). On the other hand it receives the parameters of angular deviation processed by the device 4 (connection 10) from the optronic signal provided (connection 11) by the optronic device.

Generally, the optronic surface on which are formed the image of the target and of the point of light caused by the reflector of the projectile will turn by chance about the sighting line, in particular if the sight is located on a moving vehicle. Thus, the uncorrected measurement of deviation would be, without any spatial value and thus could not be used for determining the deviations desirable for ballistic calculations. The optronic system will thus be equipped with a prismatic image rectifier or a rectifier comprising mirrors 12, a current construction of which is known by the name of PECHAN prism. This image rectifier will be controlled (connection 14) by or governed by a vertical detector 13, swinging detector (stationary vehicle) or gyroscopic detector (travelling vehicle) which is appropriately set to zero and insufficiently linear. Another particularly suitbale method is also possible when a minimum of rapid calculation means is available, which is generally the case of modern sights. One or two gravity or inertial sensors are used to measure the instantaneous angles of slope α and inclination β of the sight and by calculation the aforesaid uncorrected deviations are transferred to the horizontal and vertical deviations necessary for the correction of the uncorrected deviations Δx and Δy of the shot.

In a preferred embodiment, the firing calculator is asked to follow inreal time by calculation, the assumed trajectory of the projectile from a distance i.e. in terms of theoretical deviations with respect to the sighting line (this trajectory rejoins the sighting line at the calculated instant of impact) and to cause the laser emission shortly before said instant. On receiving the latter by return, the calculator thus takes into account the uncorrected real deviation Δx, Δy, projects them on vertical and horizontal axes and the distance of the projectile with respect to the sighting line, as mentioned previously, then by a short extrapolation calculates the assumed deviations of impact, or misses: lx, ly, lz. In view of the fact that this calculating operation is based on measurements at the end of the trajectory, the assumed and extrapolated deviations or impact or miss will be sufficiently accurate. Furthermore, nothing prevents the calculator used from being sufficiently powerful to be able to be programmed in order to use for the extrapolation the last laser echo correctly received by measuring the deviation, this also constituting a feature of the invention. The deviations lx, ly, lz are memorised and introduced into the calculation of the firing adjustments for the second shot to be fired. In this respect, it seem advantageous to provide, mainly if firing takes place on a moving vehicle, a firing sequence of two (or more) shots separated by telemetry/measurement of the deviation, which could be conveniently utilised by weapon having automatic loading and firing. This feature of the invention may be improved by the introduction into the calculator of a reference according to which the latter brings about or prohibits the second shot or one of the following if the deviations lx, ly, lz fall below a certain pre-displayed value calculated as a function of the known firing dispersion.

Figure 1 shows symbolically the automatic loading device 15 for the weapon with its control 16 itself placed under the command of the calculator 17 (connection 17) and the device 18 for aiming the weapon controlled by the calculator (connection 19).

Claims

1. A method for correcting overall, from one shot to the next, the firing of a weapon firing a projectile with a flat trajectory, characterised by the fact that the target is aimed at according to a sighting axis, the presumed moment of impact is calculated, the distance of the projectile from the sighting axis is measured at a selected moment before the said presumed moment, from this measurement, and by extrapolation of the trajectory of the projectile, the distance of the projectile from the target at the presumed moment of impact is calculated and this discrepancy is used to correct the next shot.

2. Method according to claim 1, characterised by the fact that a projectile which is capable of reflecting a beam or laser pulses is used, the projectile is illuminated with a laser beam or laser pulses (it is of advantage if it is the same laser beam as the one used for aiming at the target), the return of the reflected pulses is used to form on a detection surface, a representative point of the position of the projectile, the trace of the sighting axis of the target is formed on the same detection surface and the metric distance between the projectile and the sighting axis is calculated by means of coordinates of the said trace and of the said point and by means of determining the distance of the projectile at the said selected moment.

3. Method according to claim 1, characterised by the fact that the target is aimed with an optical sight in such a manner as to cause the optical axis of the sight to pass through the target, the image of the trace of the said axis is permanently formed on a flat photoelectric detection surface, an image corresponding to the position of the projectile is formed permanently or at programmed moments in time, the distance between the sight and and the projectile is measured permanently or at programmed moments in time and at the same moments the distance between the said hinge and the said trace is measured according to two axes passing through the said trace in order to deduce from this the metric position of the projectile in relation to the optical axis of the sight.

4. Method according to one of the claims 1 to 3, characterised by the fact that the said selected moment is determined in such a manner that the projectile at that moment is situated in front of the zone disturbed by the target when the target creates disturbances.

5. Device for implementing a method according to one of the claims 1 to 4, characterised by the fact that it includes, in combination, means (1) for aiming at the target and permanently forming throughout the duration of the travel of the projectile, an image of the target on a detection surface (3), means (2) for illuminating the projectile with pulses of light, means (6) on the projectile for reflecting the said passage towards the sighting device (1), in such a manner as to form on the said surface (3) an image of the projectile, and means (4) for calculating the distance between the projectile and the sighting axis of the target by means of the said images.

6. Device according to claim 5, characterised by the fact that the sight is equipped with a laser range-finder (2) which provides the said pulses.

7. Device according to claim 5, characterised by the fact that it includes a firing computer (7) which corrects the aiming of the weapon by means of the discrepancy calculated in this manner.

8. Device according to claim 5, characterised by the fact that it includes means for following the supposed trajectory of the projectile in actual time by means of calculation and triggering the production of light pulses a short time before the end of this trajectory.

9. Device according to one of the claims 5 to 8, characterised by the fact that it includes a device for automatic loading (15) of the weapon and for control (16) or inhibition of firing.

10. Device according to one of claims 5 to 9, characterised by the fact that a sighting device stabilised by means of a gyroscope is used.

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